

CHAPTER V - APPLIED TROPICAL CYCLONE RESEARCH SUMMARY

1. JTWC RESEARCH

Part of the mission of the Joint Typhoon Warning Center is to conduct applied tropical cyclone research as time and resources permit. The purpose of this research is to improve the timeliness and accuracy of operational forecasts. During 1980, there was continued effort to convert and update operational programs and to streamline operational procedures for compatibility with the Naval Environmental Display Station (NEDS). The following abstracts summarize the year's applied research projects which were completed or are still in progress.

EQUIVALENT POTENTIAL TEMPERATURE/MINIMUM SEA-LEVEL PRESSURE RELATIONSHIPS FOR FORECASTING TROPICAL CYCLONE INTENSIFICATION

(Dunnavan, G. M., NAVOCEANCOMCEN/JTWC)

A technique for forecasting rapid/explosive deepening has been under operational evaluation by JTWC for the past two tropical cyclone seasons. The technique indicates situations where significant intensification can be expected to occur in the near future based on the current 700 mb equivalent potential temperature and surface pressure at the cyclone center. Data from the past three tropical cyclone seasons will be collected and used to "fine tune" the temperature/pressure forecast graph. The results will then be published as a NAVOCEANCOMCEN/JTWC TECH NOTE.

TROPICAL CYCLONE WIND RADIUS PROGRAM

(Huntley, J. E., NAVOCEANCOMCEN/JTWC)

A wind radius program, developed by Holland (Bureau of Meteorology, Melbourne, Australia) was adapted for use by JTWC forecasters on a TI-59 calculator. The program requires the tropical cyclone's minimum sea-level pressure and the radius of maximum wind. This program is useful in data sparse areas in the northwest Pacific and was modified to use Dvorak satellite intensity data for Southern Hemisphere tropical cyclones.

EVALUATION OF OBJECTIVE TECHNIQUES

(Matsumoto, C. R., NAVOCEANCOMCEN/JTWC)

The 24-, 48-, and 72-hour position forecasts from the CYCLOPS steering program were evaluated during the 1980 tropical cyclone season. The unmodified and modified versions in both analysis and prognostic modes at the 500 mb level were compared against each other and against the official JTWC forecasts. Results indicate that none of the versions of CYCLOPS was able to match the official JTWC forecasts. However, the modified prognostic mode was very competitive and clearly superior to the other modes. The modified analysis mode was a close second, while the unmodified analysis mode performed poorly.

EVALUATION OF THE NAVY NESTED TWO-WAY INTERACTIVE TCM (NTCM)

(Matsumoto, C. R., NAVOCEANCOMCEN/JTWC)

The accuracy and timeliness of the new NTCM were evaluated during the 1980 tropical cyclone season. Approximately 70 NTCM forecasts were received in an ARQ mode for tropical cyclones commencing with Typhoon Norris and ending with Typhoon Dinah. The average turnaround time for these forecasts was two hours. Preliminary verification indicates that the forecasts, although more accurate than the official JTWC forecasts at 48 and 72 hours, were not as accurate as the One-Way interactive TCM that uses the analysis fields instead of 12-hour prognostic fields used by the NTCM.

A NEW TROPICAL CYCLONE FORECAST AID BASED ON A BLENDING OF PERSISTENCE AND CLIMATOLOGY (BPAC)

(Weir, R. C., NAVOCEANCOMCEN/JTWC)

A program has been designed for use with a TI-59 calculator which generates 12 to 72 hr forecasts. These forecasts are based on a non-linear persistence developed from the past 36 hr motion of a tropical cyclone and blended with climatology. The blending routine gives less weight to persistence at each forecast interval.

2. NEPRF RESEARCH

TROPICAL CYCLONE RESEARCH AT OR UNDER CONTRACT TO THE NAVAL ENVIRONMENTAL PREDICTION RESEARCH FACILITY (NEPRF), MONTEREY, CALIFORNIA

THE NAVY TWO-WAY INTERACTIVE NESTED TROPICAL CYCLONE MODEL (NTCM)

(Harrison, E. J., Jr., NEPRF)

A primitive equation, two-way interactive nested tropical cyclone model has been developed by NEPRF. Evaluation of the model as a typhoon track forecasting aid was begun during the 1980 typhoon season. The model is currently initialized from the FNOC global band prognosis fields. Within the next year the model will be coded for the new CYBER 203 computer being installed at FNOC, and will be initialized from the new global model prognosis fields.

THE PERFORMANCE OF THE NTCM WHEN INITIALIZED WITH GLOBAL BAND ANALYSES VERSUS GLOBAL BAND 12-HR PROGNOSSES VALID AT THE SAME TIME

(Fiorino, M. and Harrison, E. J., Jr., NEPRF)

The present version of the NTCM is ini-

tialized with 12-hr old global band prognostic fields because the tau zero analysis is not available until several hours past warning time. The performance of the model in 1980 was not as good as expected considering the results of the developmental evaluation using test cases. Most of the difference is thought to be because the test cases were initialized with analyses. The 1980 forecasts are now being recomputed with tau zero analyses. Initial results show differences which hopefully can be quantified with more cases.

THE EFFECT OF HEATING ON TYPHOON TRACK FORECASTING USING THE NTCM

(Fiorino, M., NEPRF)

A major difference between the NTCM and other typhoon model is the analytic representation of the diabatic effects of cumulus convection. To determine which characteristics of the heating field have the largest influence on the track, the heating profile is varied in space and time. Once these characteristics (magnitude, spatial distribution, etc.) have been identified, an attempt will be made to find an optimum set of heating parameters for several storms which can be related to satellite observations.

PREDICTING TROPICAL CYCLONE FORMATION IN WESTPAC

(Lowe, P. R., NEPRF)

The "Genesis" program has been evaluated from spring 1980 to fall 1980. The procedure has correctly forecast all tropical cyclone development during this time period. Further, false alarms were minimal in that only one case was forecast to develop which subsequently did not develop (TD-10). One problem was isolated during the evaluation. During the months of August and September, "Genesis" was prone to forecast development somewhat prematurely. Subsequent analysis of the program determined and corrected the cause of the problem. "Genesis" became operational in early October. A formal technical report on "Genesis" performance for the year 1980 is planned.

TROPICAL CYCLONE STRIKE AND WIND PROBABILITY

(Brand, S., NEPRF, Jarrell, J. D., Science Applications, Inc., and Chin, D., Systems and Applied Sciences Corp.)

Tropical cyclone strike and wind probability is a method for determining up through 72-hr that a tropical cyclone will come within or affect geographic points of interest to the user. The output from this program can be used as an aid for operational decisions associated with tropical cyclone evasion, evacuation, and base preparedness. Applications presently being developed, tested and implemented include: strike and wind probability and geographic depictions in the western North Pacific; optimum track ship routing (OTSR) aspects in the western North Pacific; eastern North Pacific strike probabilities; and western North Atlantic and Gulf of Mexico strike probabilities.

TROPICAL CYCLONE HAVEN STUDIES

(Turpin, R. and Brand, S., NEPRF)

Six additional ports and harbors have been evaluated and will be forwarded as change TWO to the Typhoon Havens Handbook for the Western Pacific and Indian Oceans. In addition, COMSECONFLT and CINCLANTFLT have requested 22 ports and harbors in the Atlantic and Gulf of Mexico be evaluated as hurricane havens. Work has commenced on these port studies.

SOUTHERN HEMISPHERE UPPER-LEVEL TROPICAL CYCLONE STEERING TECHNIQUES

(Hamilton, H., Systems and Applied Sciences Corp.)

The current automated objective steering forecast technique (operationally termed CYCLOPS) has been developed for operational forecast use in the Southern Hemisphere.

TROPICAL CYCLONE SURFACE WIND DISTRIBUTION

(Tsui, T., Brand, S., and Brody, L. R., NEPRF)

Based on data from 1966 to 1977 JTWC tropical cyclone warnings, a statistical wind distribution forecast model has been developed and tested. The results of the statistical test, using the independent data of the 1979 tropical cyclone season, showed that the 30-kt and 50-kt wind radius forecast model provides competitive automated forecasts as compared to the official forecasts of JTWC. The asymmetric nature of a tropical cyclone is incorporated in the model. In addition, a by-product of this model is suggested wind radius information in a format for insertion into the tropical cyclone warning.

TROPICAL CYCLONE INTENSITY

(Tsui, T., Brody, L. R., and Brand, S., NEPRF)

A climatology/persistence tropical cyclone intensity forecast model has been developed. The data base consists of 1966 to 1979 western North Pacific tropical cyclones. Synoptic variables such as equivalent potential temperature are now being incorporated as predictors in the model. Two other predictors which may be included in the future are the cloud-top temperature pattern and the spiral pattern of the cloud bands derived from the satellite IR and visible imagery, respectively.

SATELLITE BASED TROPICAL CYCLONE INTENSITY FORECASTS

(Brody, L. R. and Tsui, T., NEPRF)

The Satellite Processing and Display System (SPADS) is being used both to test available statistical algorithms and to develop new statistical algorithms which make

24-hr forecasts of changes in tropical cyclone intensity. These statistical algorithms are based on satellite-measured equivalent blackbody temperatures of cloud tops surrounding tropical cyclones. IR data for both GOES-EAST and GOES-WEST for the 1979 tropical cyclone season are being used in this study.

AUTOMATIC EXTRACTION OF TROPICAL CYCLONE SATELLITE WINDS

(Lee, D. H., NEPRF)

Satellite winds of the quality, quantity, and density necessary for initialization of tropical cyclone models can be quickly extracted from successive geostationary satellite images using the System for Automatic Wind Extraction from Geostationary Satellite-data (SAWEGS). This recently developed system used Fast Fourier Transforms to extract cloud winds by computing the cross-covariance between images, and includes a unique edge enhancement technique plus other features which allow the automatic production of winds in tropical cyclone cases. Recent studies of the application of SAWEGS to tropical cyclone image sets have shown the good quality and coverage of resulting vectors as well as the system's remaining difficulties.

TROPICAL CYCLONE SPIRAL LINEARIZATION TECHNIQUE

(Lee, D. H., NEPRF)

A new technique for quantizing information inherent in the spiral banding structure of tropical cyclones has been developed. The Spiral Linearization Technique involves the transformation of a satellite image to polar stereographic coordinates and subsequent remapping into a selected spiral coordinate system. Cloud structures which conform to the spiral shape are portrayed as linear formations after linearization. Statistical and quantitative analyses of the linearized image yield information on a cyclone's structure which can be correlated with the cyclone's characteristics and behavior. A system to apply this technique is under development on the NEPRF Satellite-data Processing and Display System.

3. PUBLICATIONS

Duinavan, G. M., and Diercks, J. W., 1980: An Analysis of Super Typhoon Tip (October 1979), Monthly Weather Review, Vol. 108. pp 195-203.

Super Typhoon Tip was an eventful tropical cyclone which developed in the western North Pacific in early October 1979. Besides establishing the world's record for the lowest minimum sea level pressure ever measured in a tropical cyclone, Tip also possessed the largest surface circulation pattern ever observed for a tropical cyclone. The development cycle of Super Typhoon Tip from a weak disturbance to a mature typhoon to an extratropical system is discussed in view of the record breaking performance of this typhoon.

Guay, G. A., 1980: Tropical Cyclone Forecast Verification as a Function of Reconnaissance Platform, NAVOCEANCOMCEN/JTWC 80-3, TECH NOTE.

Harrison (1975) examined tropical cyclone forecast accuracy as a function of the reconnaissance platform used as the basis for each forecast's initial position. Using 1973 and 1974 data, Harrison showed that forecasts based on aircraft position fixes were most accurate when compared to the Joint Typhoon Warning Center's best tracks. Unlike the earlier study, forecasts based on satellite reconnaissance were more accurate than forecasts based on aircraft reconnaissance for tropical cyclones which never reached typhoon intensity.

Lubeck, O. M., and Shewchuk, J. D., 1980: Tropical Cyclone Minimum Sea Level Pressure Maximum Sustained Wind Relationship, NAVOCEANCOMCEN/JTWC 80-1, TECH NOTE.

This paper investigates empirical relationships between maximum sustained surface winds and minimum sea-level pressure in western North Pacific tropical cyclones. The empirical equation developed by Atkinson and Holliday (1977) is reviewed and evaluated using 13 independent cases collected since the original study. New relationships were developed using the original dependent data set in Atkinson and Holliday and were tested also against the 13 independent cases. These new relationships were based on different assumptions for reducing observed peak wind gusts to one-minute sustained surface winds. There were no significant differences between the original Atkinson and Holliday relationship and the new relationships. Introducing environmental pressure and latitude as additional predictors did not improve the pressure-wind relationship.

Shewchuk, J. D., and Weir, R. C., 1980: An Evaluation of the DVORAK Technique for Estimating Tropical Cyclone Intensities from Satellite Imagery. NAVOCEANCOMCEN/JTWC 80-2, TECH NOTE.

This paper investigates the accuracy of tropical cyclone intensity estimates as derived from the Dvorak technique. Estimates of current intensity and 24-hour forecast intensities were verified against JTWC official best track data. Results from a 396-case sample indicate overall absolute and bias errors of less than one CI number, even though forecast intensity errors were twice that of the current intensity estimates. Comparison of Dvorak and JTWC intensity errors indicate that they are essentially equal. The Dvorak 24-hour forecast intensities are also superior to all objective forecast aids available to the JTWC. Dvorak forecast data were also evaluated as a function of the tropical cyclone's life cycle. Results show a tendency of the Dvorak technique to over-forecast developing and weakening trends. Verification of cases which included a PLUS or MINUS symbol indicated no improvement over cases with no symbols. However, the use of the symbols is believed to reduce forecast intensity error.